UA9 results, status and plans both in SPS and LHC

Valentina Previtali on behalf of UA9 collaboration

Minimal outline

- **SPS** (UA9 results)
- **LHC** (Status and plans)

Present and comment slides from the recent UA9 collaboration meeting at CERN

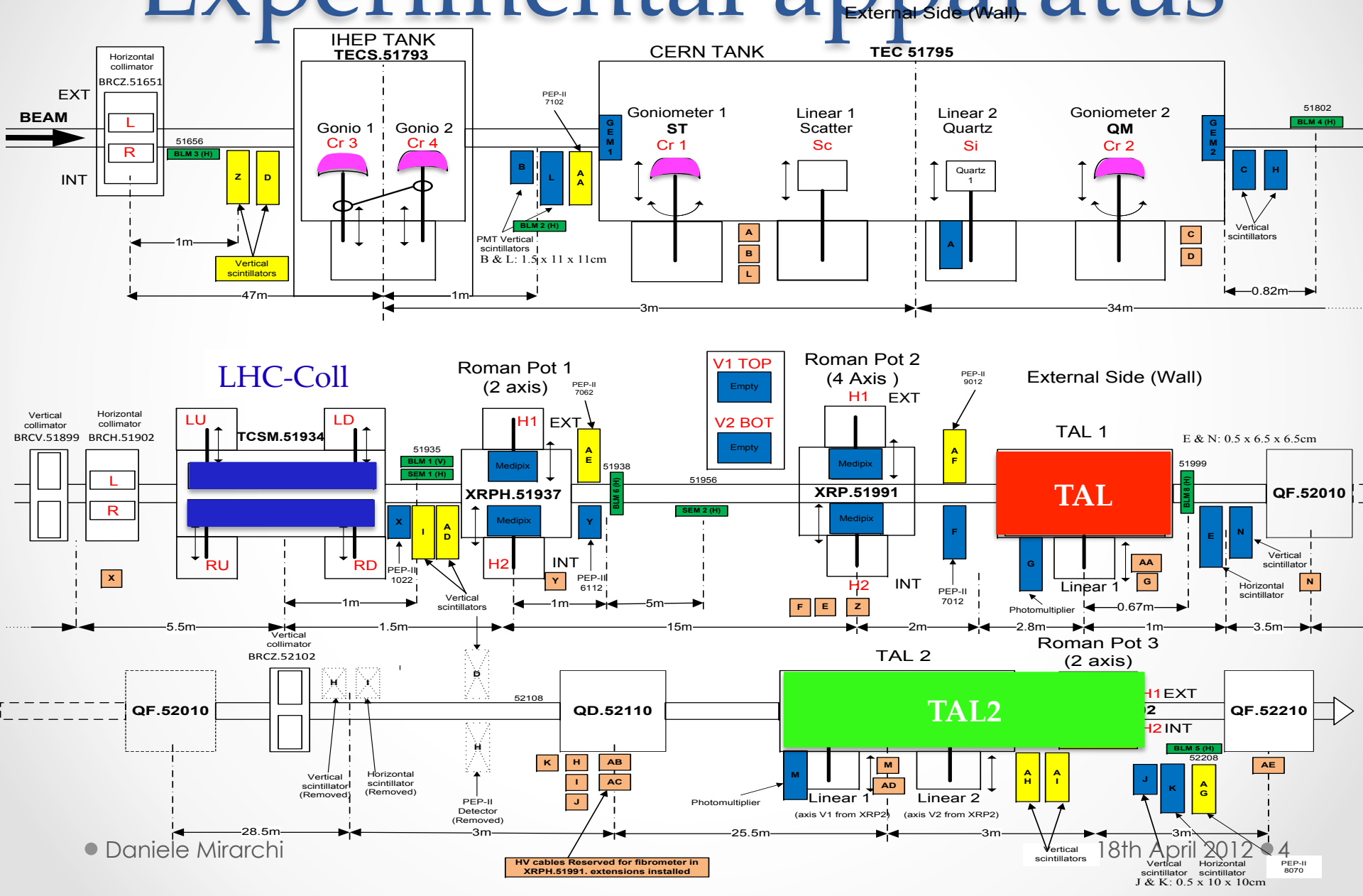
SPS results with protons 2011 runs

Valentina Previtali, Roberto Salemme, Branislav Ristic
Daniele Mirarchi
CERN, Imperial College London

UA9 Collaboration meeting
18th April 2012

➢ Commented…

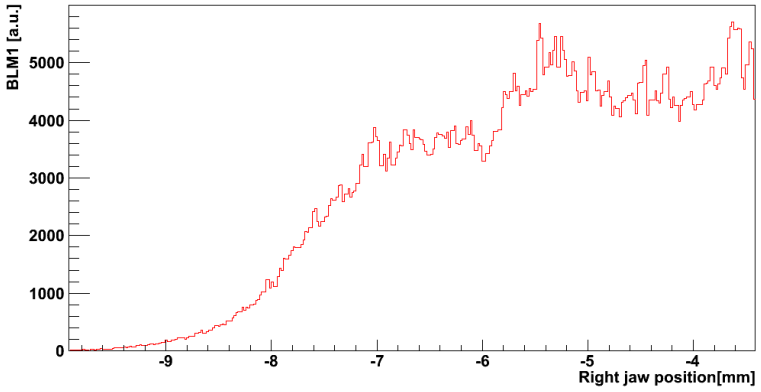
Experimental apparatus



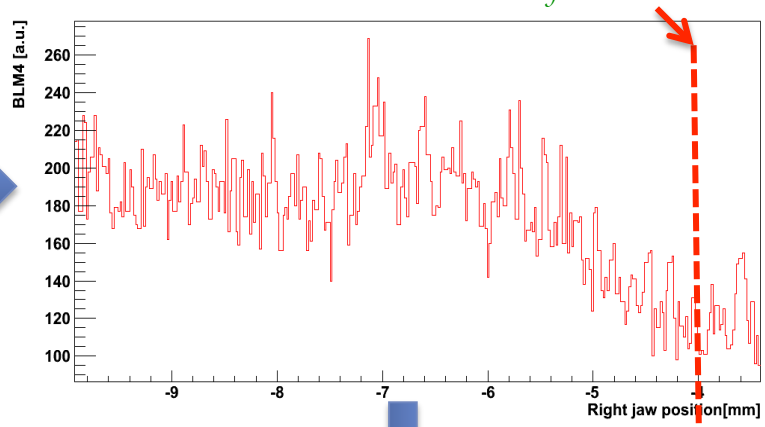
LHC-Collimator Scans

Only one scan done at the end of the MD done the 7th July.

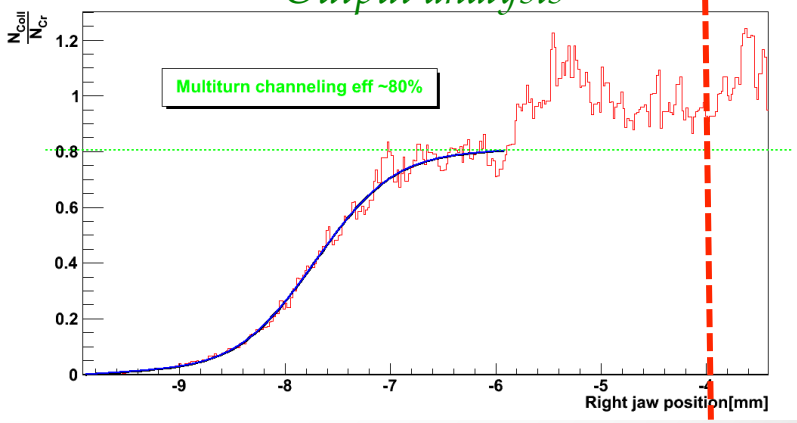
Raw data



Losses at Cr VS Coll. pos.
to estimate when $A_{coll}=A_{cry}$ (~-4mm)



Output analysis



Valid if we assume:

1. Segnal BLM $\propto N_{coll}$
2. If $A_{coll}=A_{cry} \rightarrow N_{coll}=N_{cry}$

N: particles at collimator/crystal
A: aperture of collimator/crystal

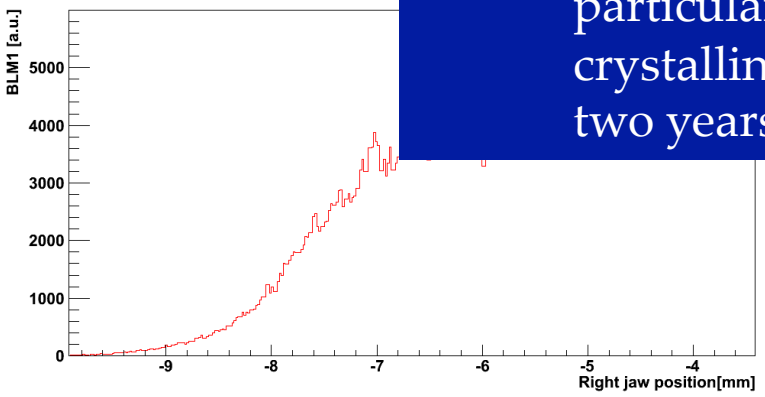
Multiturn channeling efficiency measured ~80%

LHC-Collimator Scans

Only one scan done at the end of the MD done the 7th July.

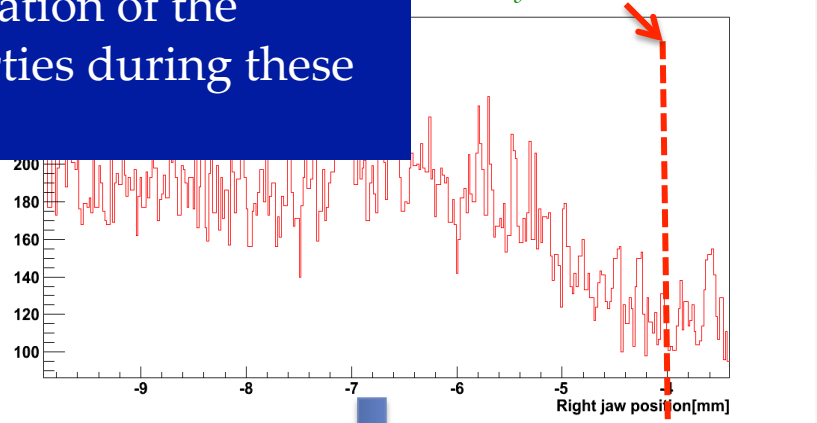
- 80% efficiency confirmed. no particular degradation of the crystalline properties during these two years of tests

Raw d

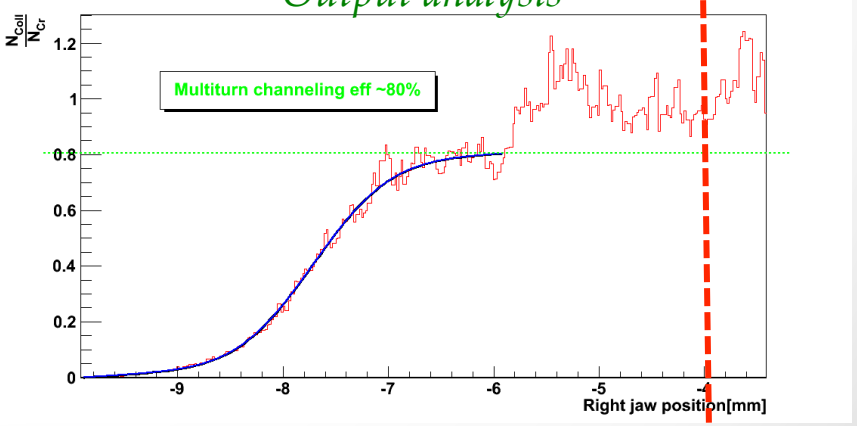


S Coll. pos.

$_{oll}$=A$_{cry}$ (~-4mm)



Output analysis



Valid if we assume:

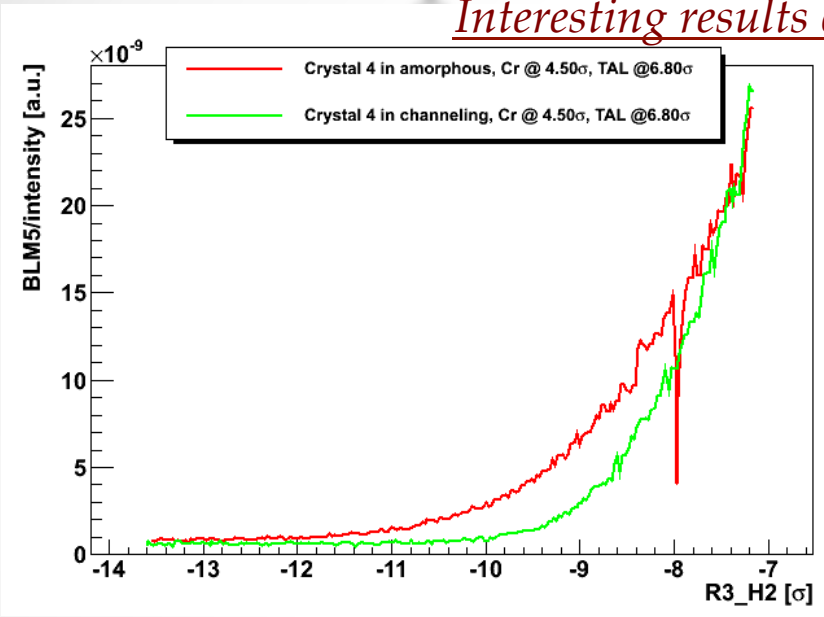
1. Segnal BLM $\propto$ N_{coll}
2. If $A_{coll} = A_{cry} \rightarrow N_{coll} = N_{cry}$

N: particles at collimator/crystal
A: aperture of collimator/crystal

Multiturn channeling efficiency measured ~80%

Dispersive Area Scans

Interesting results obtained in the deep scan (July run)



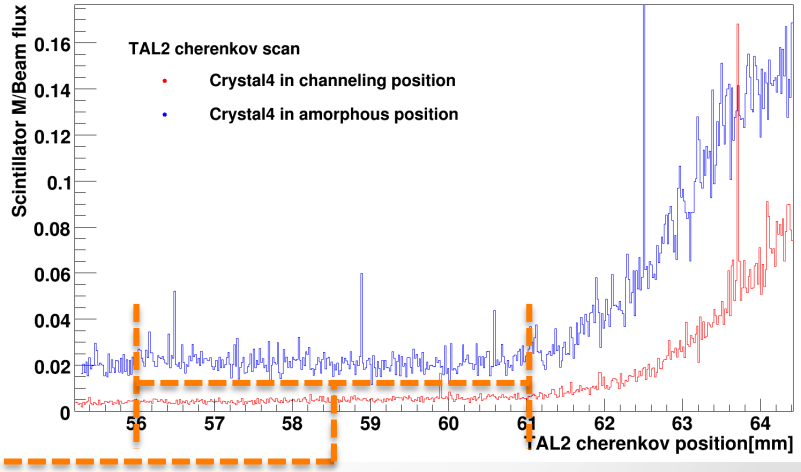
Deep scan till the TAL aperture:

- Same level of losses at the TAL aperture!
- Shown in the picture the whole tertiary halo that escape from the collimation insertion:
  - ✓ More spread of the halo in AM orientation w.r.t. CH orientation
  - ✓ large reduction until -10σ (from the beam)
  - ✓ reduction after -10σ affected from detector feature (electronic background bigger than losses created by the scraper)

Feature clearly visible using the Cherenkov data (2010):

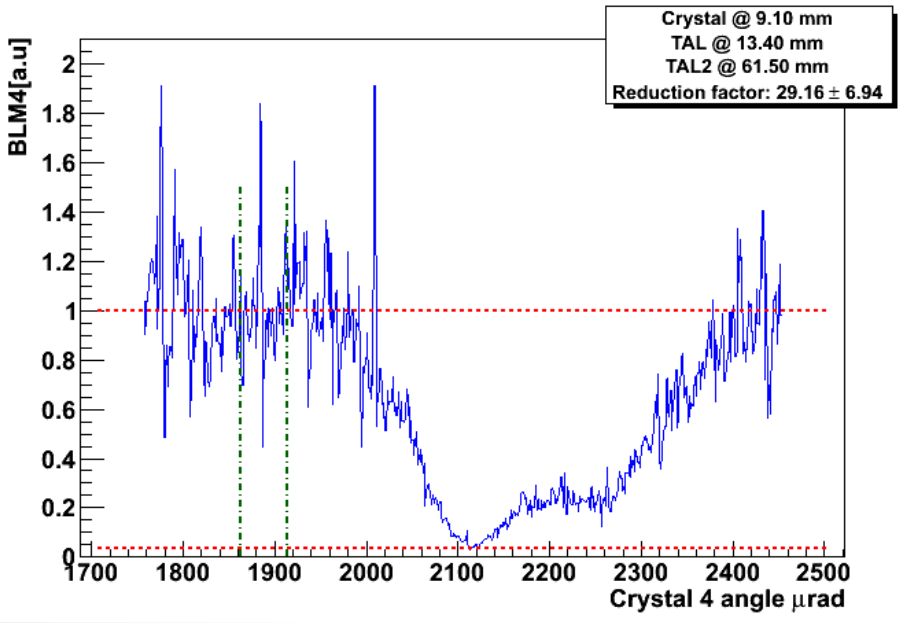
- ➢ direct particles detection inside the beam pipe
  - ✓ reduction still increasing after -10σ

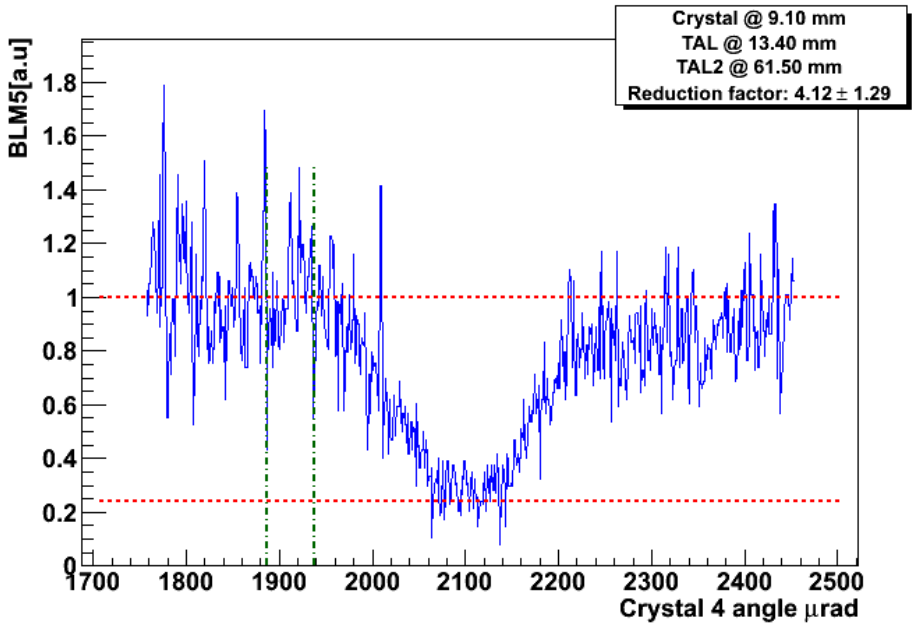
- ➢ Clear reduction of tertialy beam halo in channeling as measure by different detectors



Angular Scans

Example of data quality for the scans taken in account:



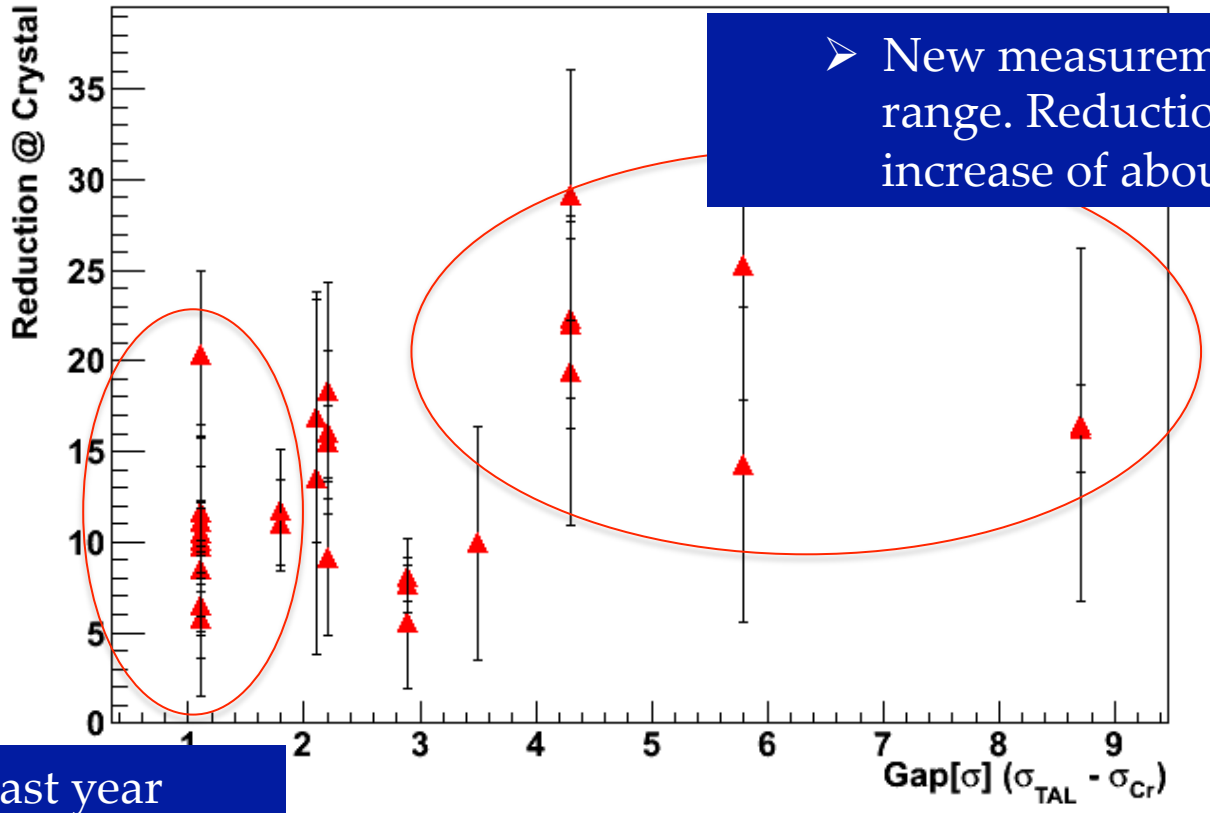


BLMs at Crystal location and TAL2 location.

- Factor about 10 inelastic interaction reduction at the crystal, about a factor 5 in dispersive areas

Angular Scans

Interesting behavior of the reduction factor at Crystal in function of the gap between Cr & TAL:

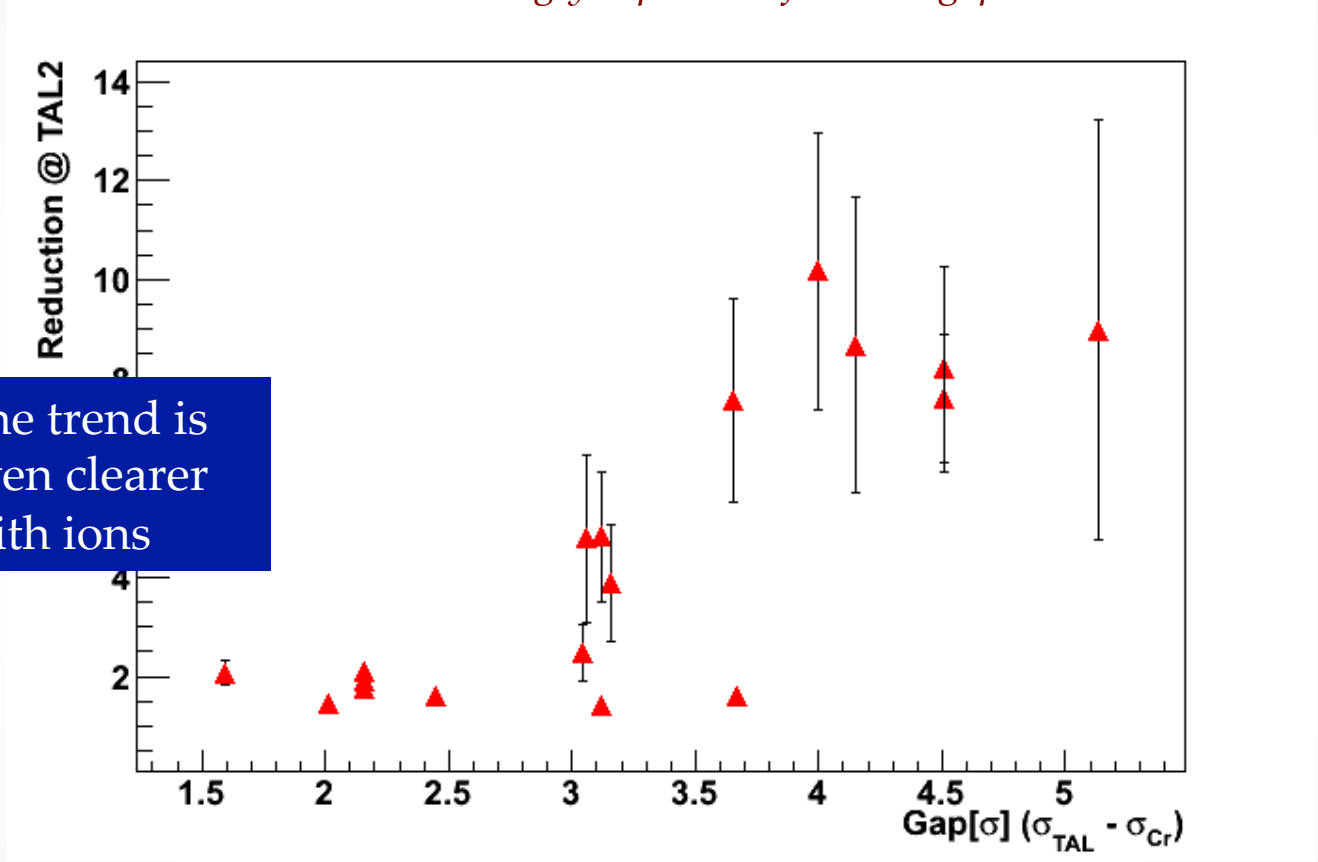


- New measurement in wider range. Reduction factor increase of about a factor 2
- Last year reproduced

- ✓ Reduction factor approach to the value expected by Taratin's simulations, but at ~4-6σ!
- ✓ Reduction factor coherent with what found in the past where was used a gap of ~1-3σ!
- ✓ Same behavior in case of ions as shown in the next presentation!

Angular Scans

Reduction at TAL2 location strongly dependent from the gap between Cr & TAL:



- The trend is even clearer with ions

- ✓ As at the crystal location increase of the reduction factor at ~4σ, but here much more evident!
- ✓ Completely different from the protons run in which non dependence has been found!

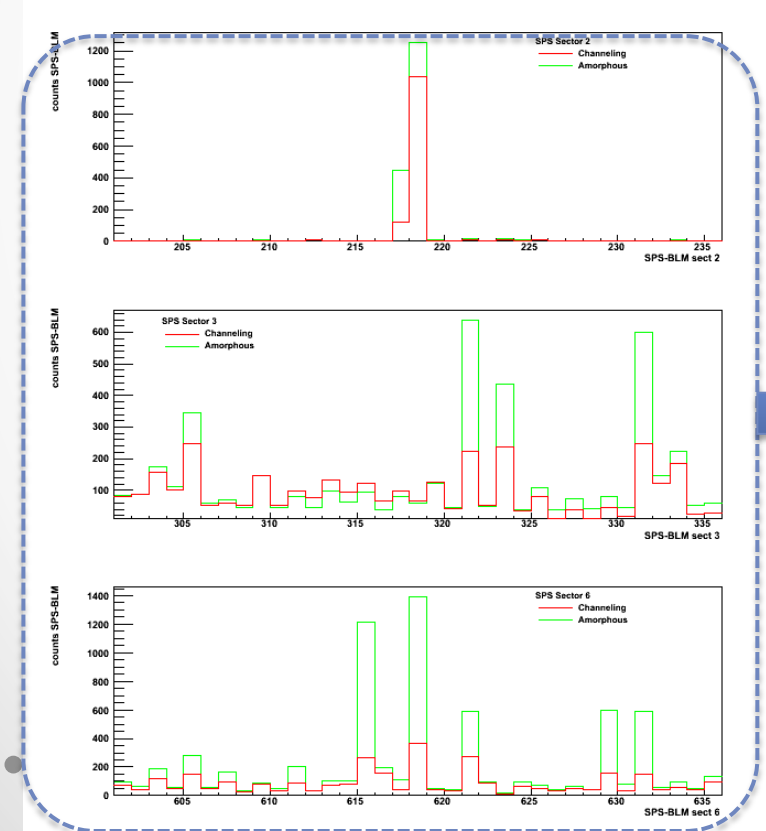
SPS Loss-Map

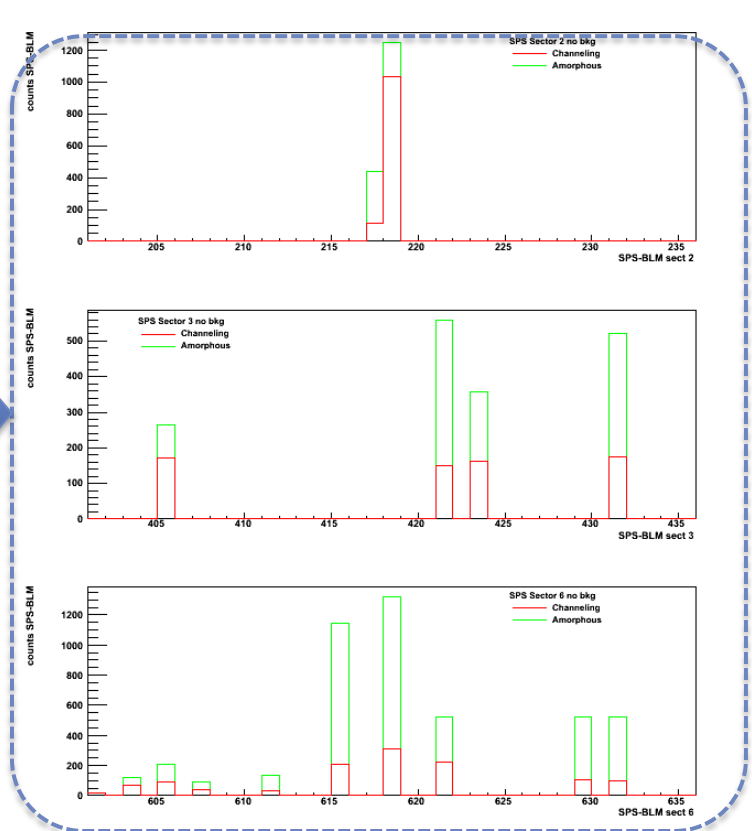
Overview:

- Level of losses starts to be seen (Oct. run with 48 bunch), but still needed better detectors settings (only 16 BLMs good)
- Background estimation done using the average value of losses seen by the SPS-BLM that are not in the linear regime (neither in saturation) and in the same SPS sextant of the good ones
- Loss Map measured during the angular scan

➢ Poor equipment to measure the losses along the machine

Raw data





Background subtracted data

LHC Status and PLANS

- Instrumentation
  - Goniometer
  - Detectors
    (present workshop at Imperial College)
  - Crystal 5 mm Si crystals, about 50 μrad (1 Ferrara, 1PNPI), to be tested in H8
- First collimation studies

Goniometer

- **3 options:**
  - 1 Goniometer based on piezoelectric sensors (CERN EN-STI)
  - 2 push-pull technology
    - IHEP
    - CINEL

Plans for an optimal goniometer

A. Masi

Contents

1. Goniometer requirements for LHC
2. Promising technology: Piezo-Actuactors
3. Preliminary Results
4. Promising technology: Interferometric nanometric feedback position sensors
5. Conclusion and outlooks

Total angular range : >10 mrad
Resolution: <0.1 μrad
Accuracy: < 1 μrad

- Impressive resolution. It could really be helpful for high energy, when the angular acceptance is tight (~2urad)

- Piezo actuactors are potential candidates to be used for the LHC goniometers for the high positioning resolution achievable
- Radiations effects on piezo actuactors are being studied
- Piezo goniometers can reach the positioning accuracy required by the LHC only in closed loop
- The problem moves to the angular sensor used to close the loop. It has to fulfill the accuracy requirements and to be rad-hard
- Interferometric sensors based on optical fiber are under study

- Initially rejected because of the $$ - now it looks like the prices dropped to a reasonable amount (sensor from 150K$ to 20K$)
- Still on design phase – maybe tested in H8 at the end of this year?

INFN-CERN
CINEL Goniometer

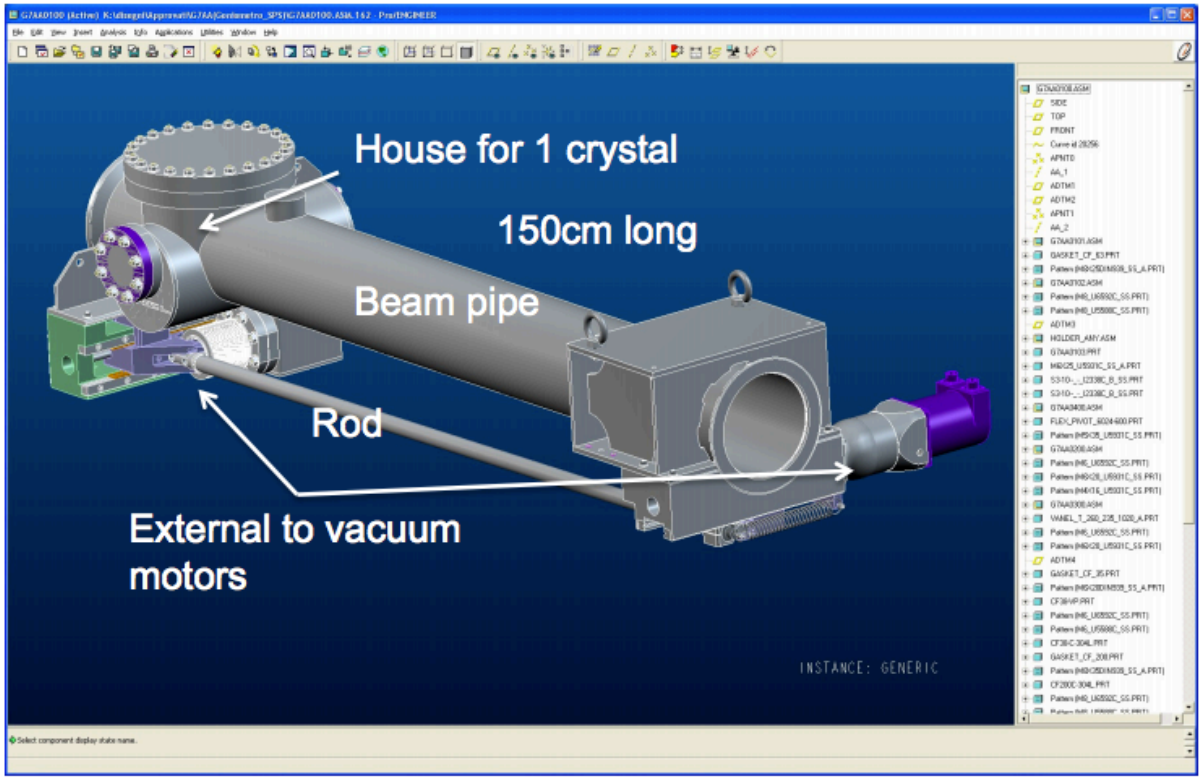
- Italian company scientific instrumentation

G.Cavoto
INFN Roma
Apr 18th 2012
UA9 Collaboration meeting

Purpose

- Build a device with all the specs valid for LHC.
  - Total angular range : >10 mrad
  - "Resolution": <0.1 μrad
    - Minimum step of motor
  - "Accuracy": < 1 μrad
    - How precisely the motor goes to a given ang. position
    - Related to channeling critical angle scale
  - Maximum tilt inaccuracy: < 1 μrad
    - Linear-angular coupling,…
  - Linear resolution: 5 μm
- Total linear range: 40 mm
- Prepare it in due time to be tested on SPS in 2012
  - Clearly some modification needed (i.e. beam pipe diameter)

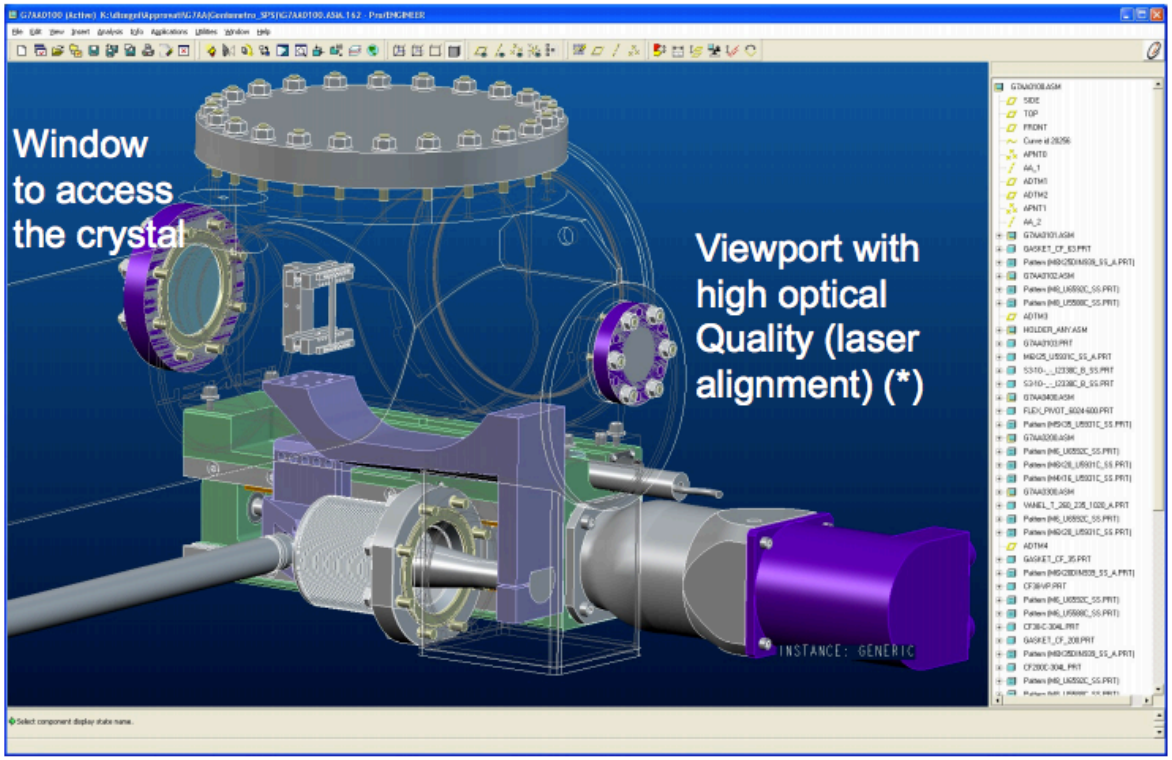
Full picture



Compact design

Linear range : 100 mm
Angular range: 100 mrad

Crystal house



(*) not
included

IHEP GONIOMETER IN 2012

Yury Gavrikov (PNPI, Gatchina, Russia)

- Prototype already installed in SPS

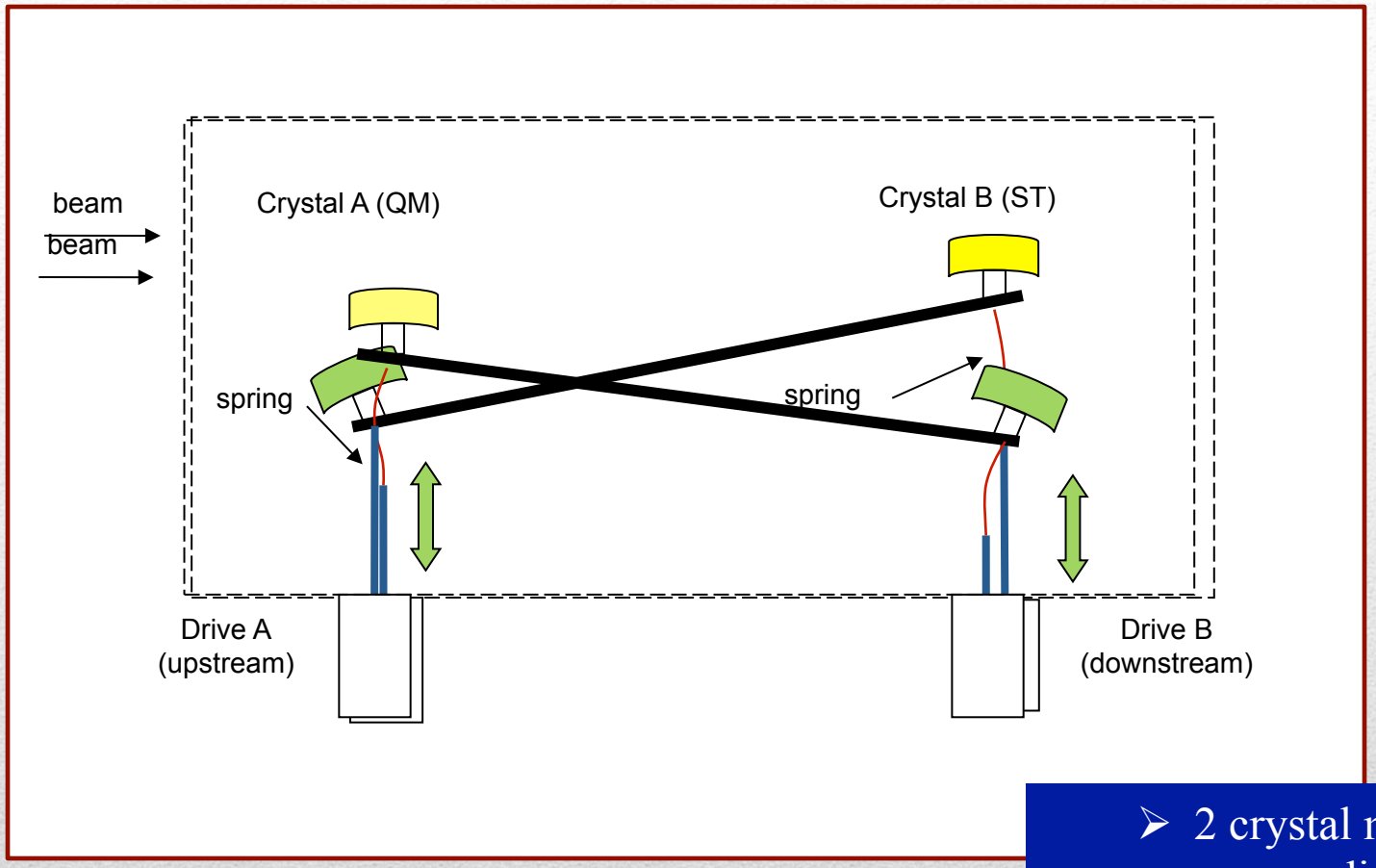
Characteristics

The goniometer have been redesigned

- Angular range +/- 20 mrad
- Minimal step ~ 1.1 urad (full step of motor)
- Crystal in parking > 85mm from beam axis
- Linearity (?) – to be checked in the next access
- Vibrations (?) – to be checked in the future

➢ For the current prototype, the resolution is 10x worse than the other options (on paper, but in reality?)

➢ Long arms -> vibration problems (as seen in FNAL, T980)

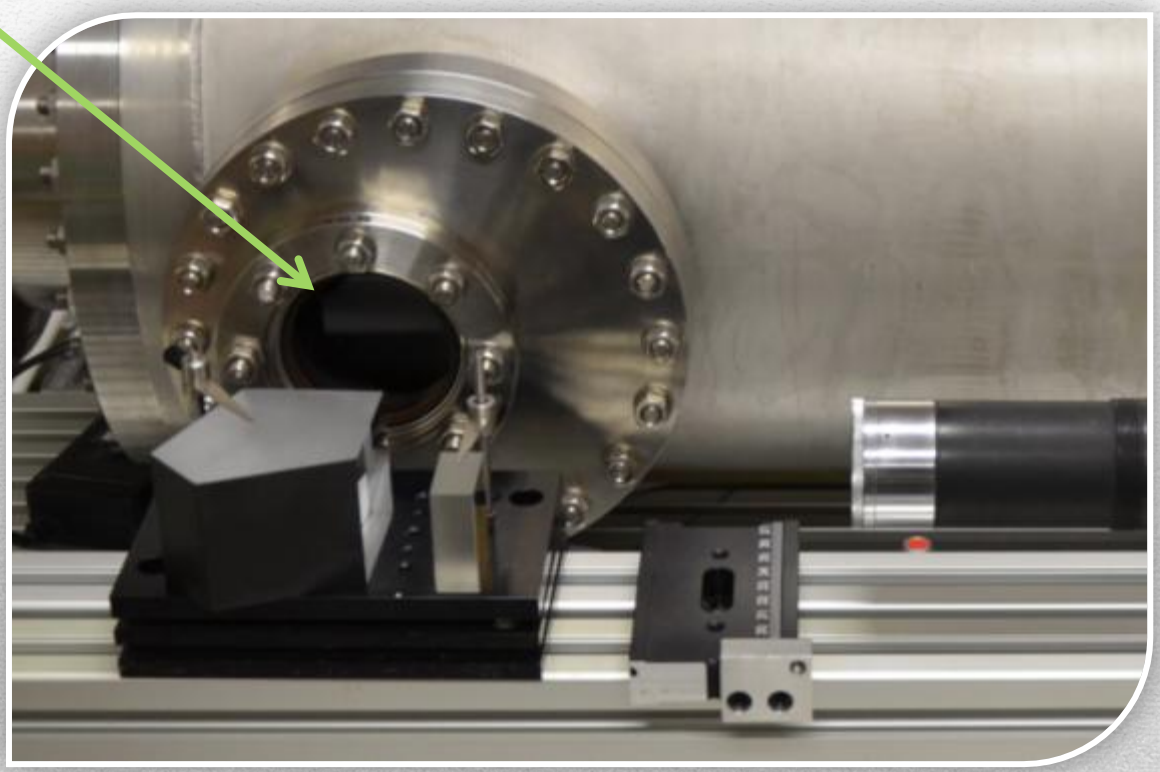


- 2 crystal mounted – same direction

IHEP goniometer idea

- Increased diameter of viewports for the alignment

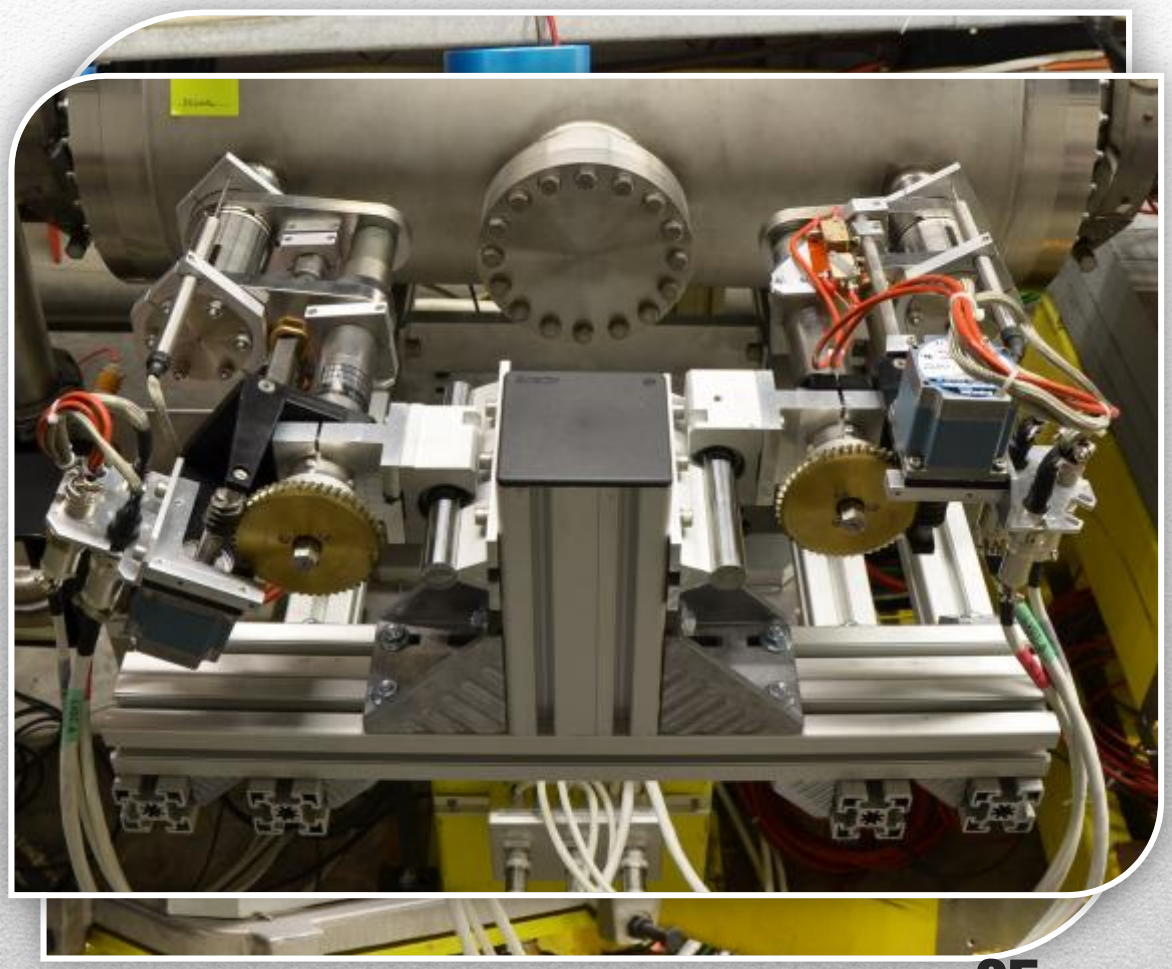
From 30 up to 60mm



Improved

- Possible crystal vibrations

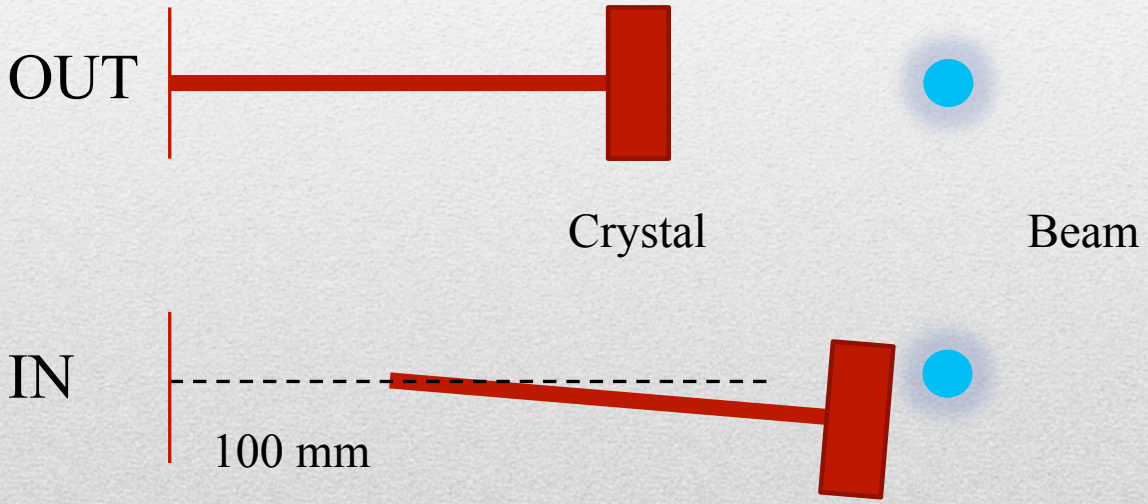
The special support developed to decrease the horizontal freedom of tilt & vibration



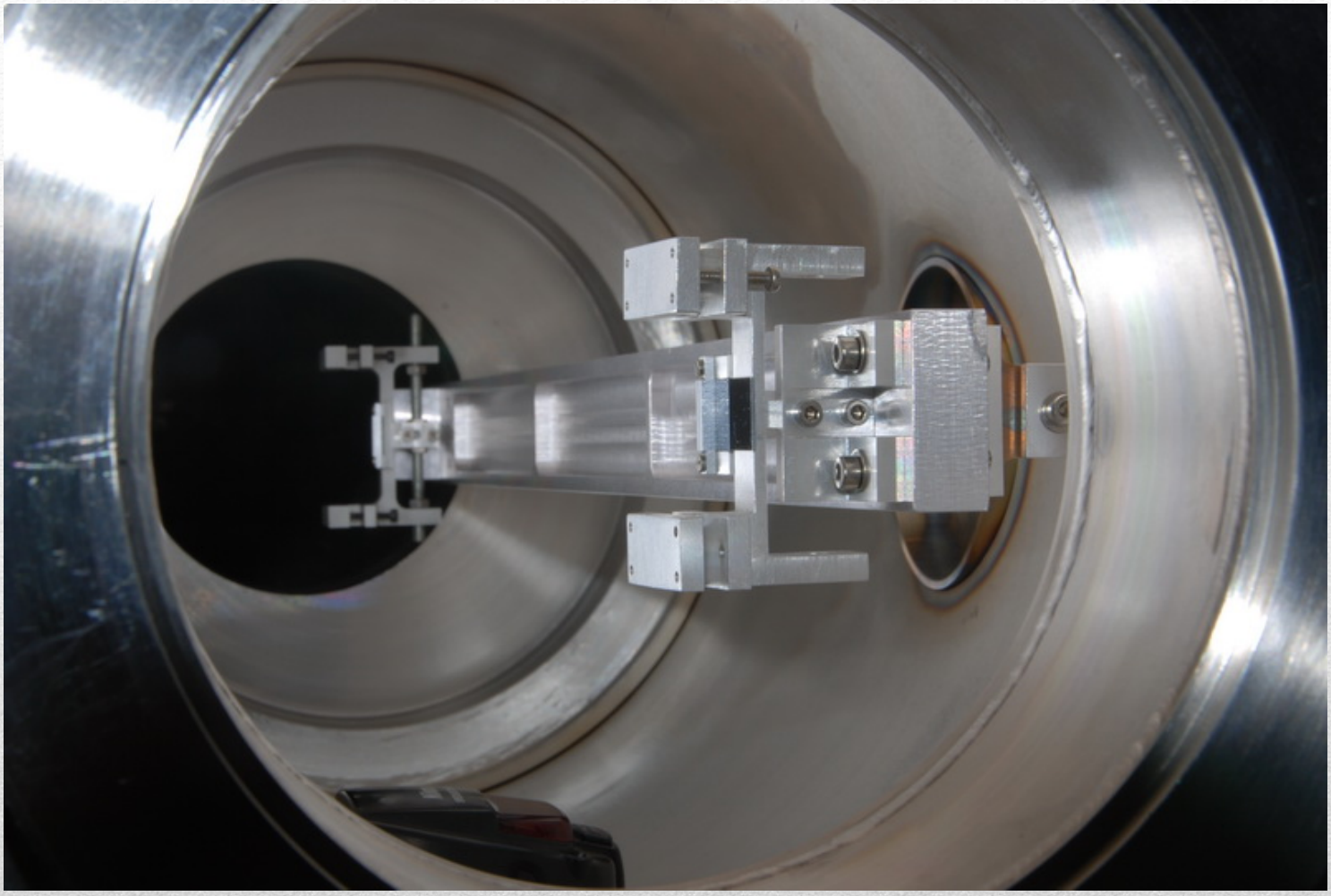
Reduced

- Vertical tilt/shift at IN/OUT positions reduced

1 mrad (v. 2010) -> 100 urad (v. 2012)



Reduced



Crystals in IHEP gonio

Perspectives

- **Motorization without vibrations**
  - for **smooth** motion in continuous mode if it is needed
- Motorization without mechanical play
  - for immediate motion in opposite direction

- **“Close loop” for crystal positioning**
  - Optical online angular measurement system
  - Other possibilities(?)

LHC possible installation locations

- **New layout/integration studies (F. Galluccio) in IP7**

- Full tracking simulations performed with Sixtrack only for the "natural" location – (my phd thesis, 2010)
  - Results: Gain in cleaning efficiency of a factor 20 for the perfect crystal in the natural location
  - Optimization of the angle performed, optimal angles found between 40 and 50 μrad for both horizontal and vertical planes

LHC LAYOUT STUDIES

Francesca Galluccio
INFN

The UA9 experiment in the LHC

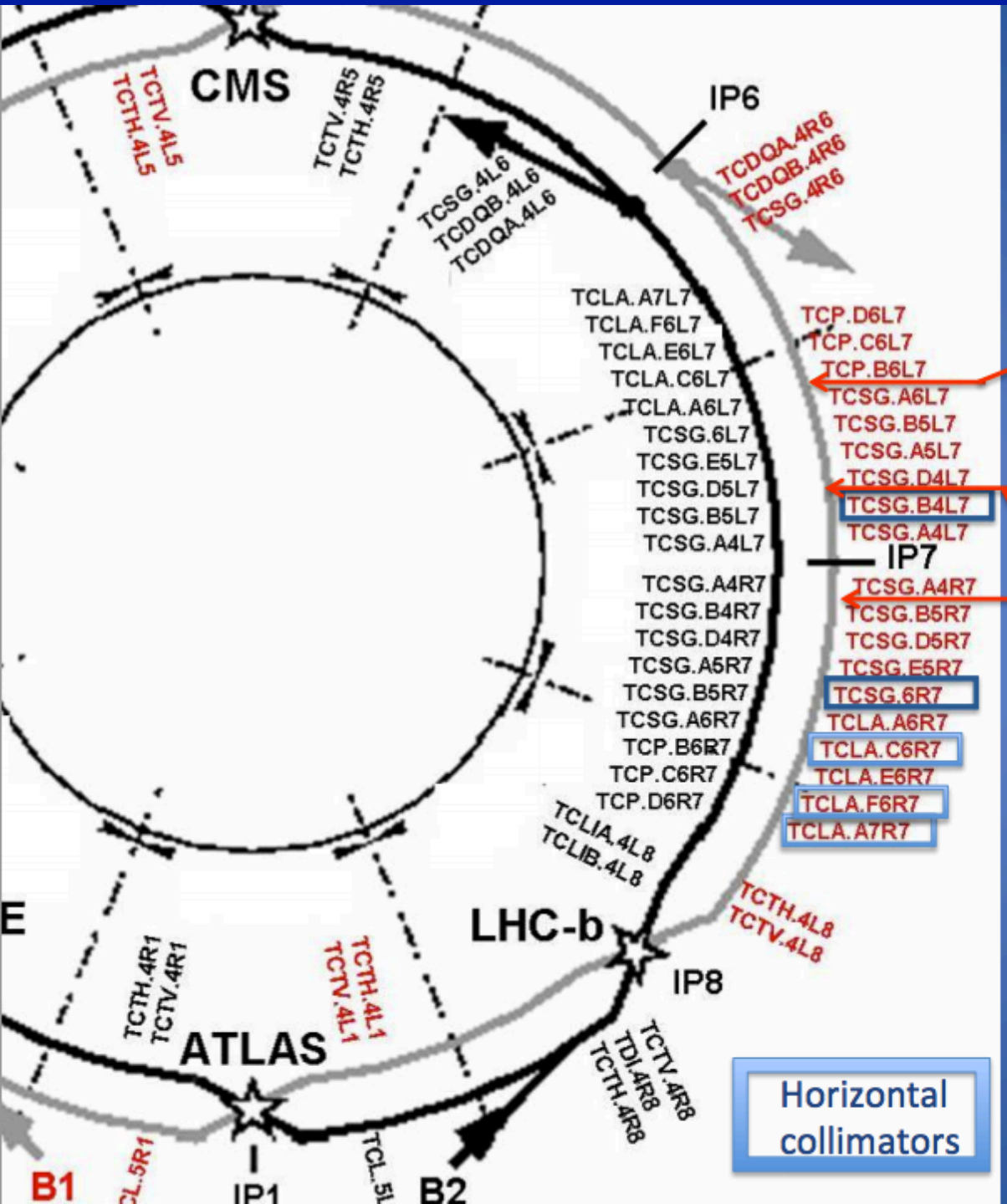
We started planning for a very safe and cautious experiment (this talk):

- With pilot bunches
- At injection energy (450 GeV)
- Only 1 crystal, in the horizontal plane
- With the standard collimators in place

We might be allowed to be more ambitious, and release some of these conditions (go to High Energy, move the collimators, eventually increase the current)

We want to introduce the minimal perturbation to the present setup:

- Use space already free for goniometer with crystal and Roman Pot
- Use the collimators where they are already available in the machine



Several positions

<u>Natural choice:</u>
In the primary region
TCP.A6L7
Option put aside due to high radiation level in the area

<u>Suggested location:</u>
TCSG.B4R7
and upstream
Lower radiation and easy access via UJ76

<u>Alternative location:</u>
TCSG.C4L7

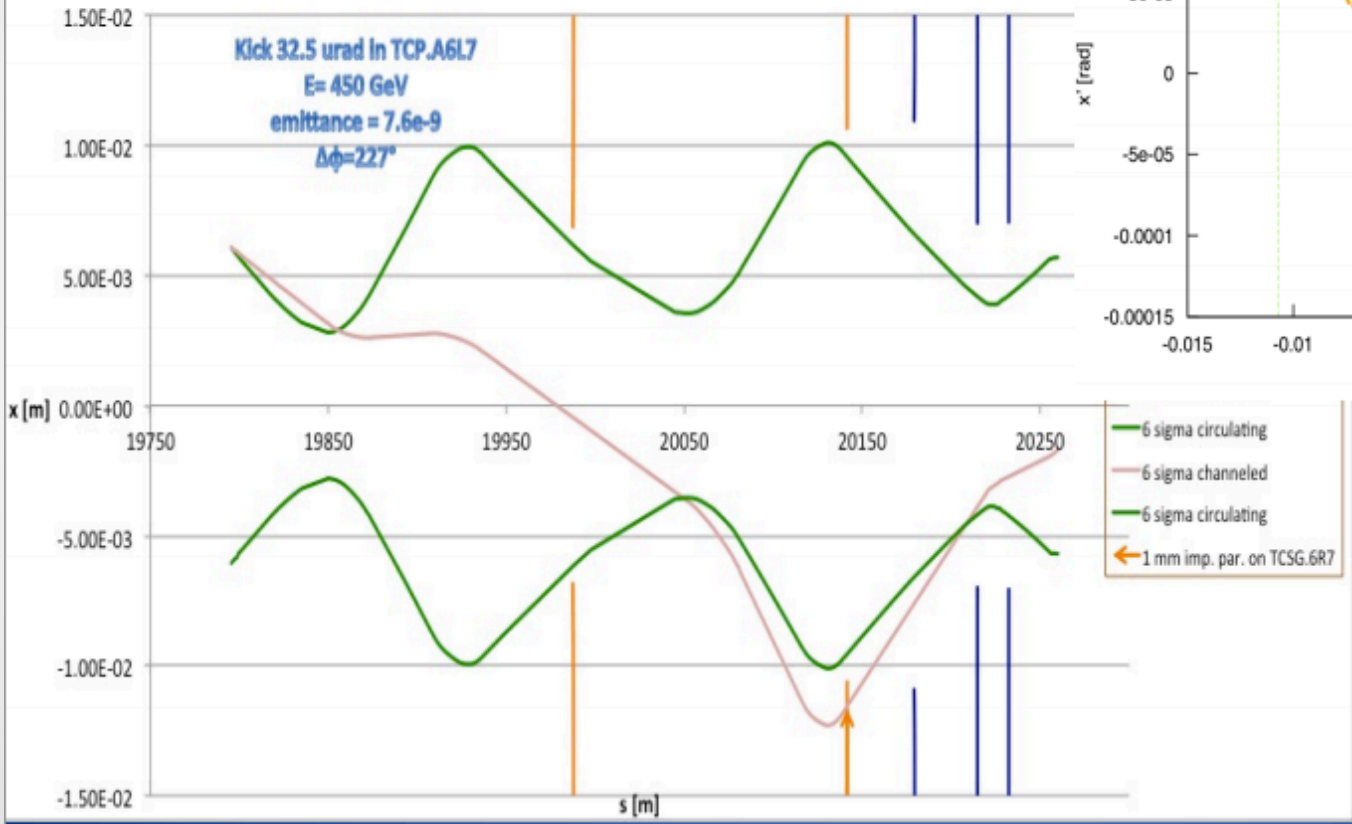
<u>Location proposed</u> by Integration group (J.P. Corso) immediately downstream TCSG.C4L7
Convenient for space availability

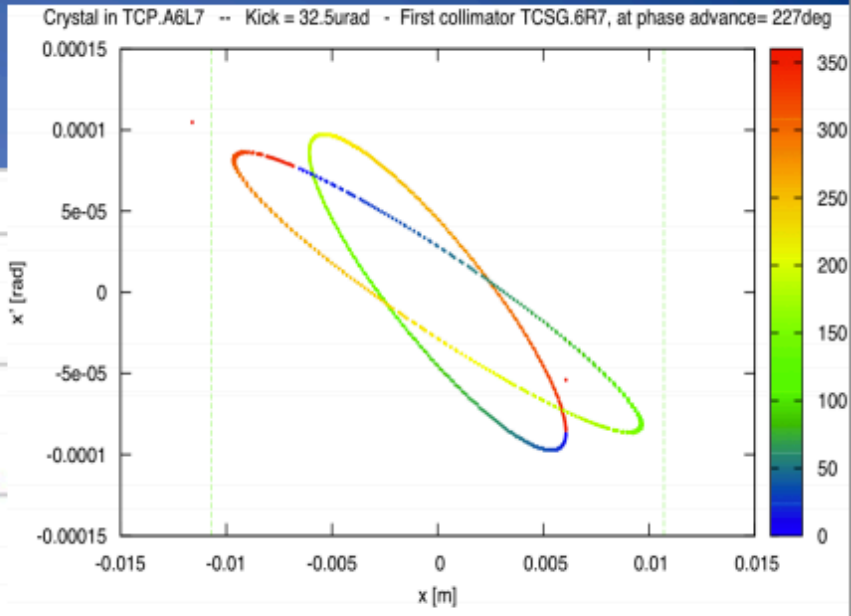
Natural choice:

In the region of primary collimators

TCP.A6L7

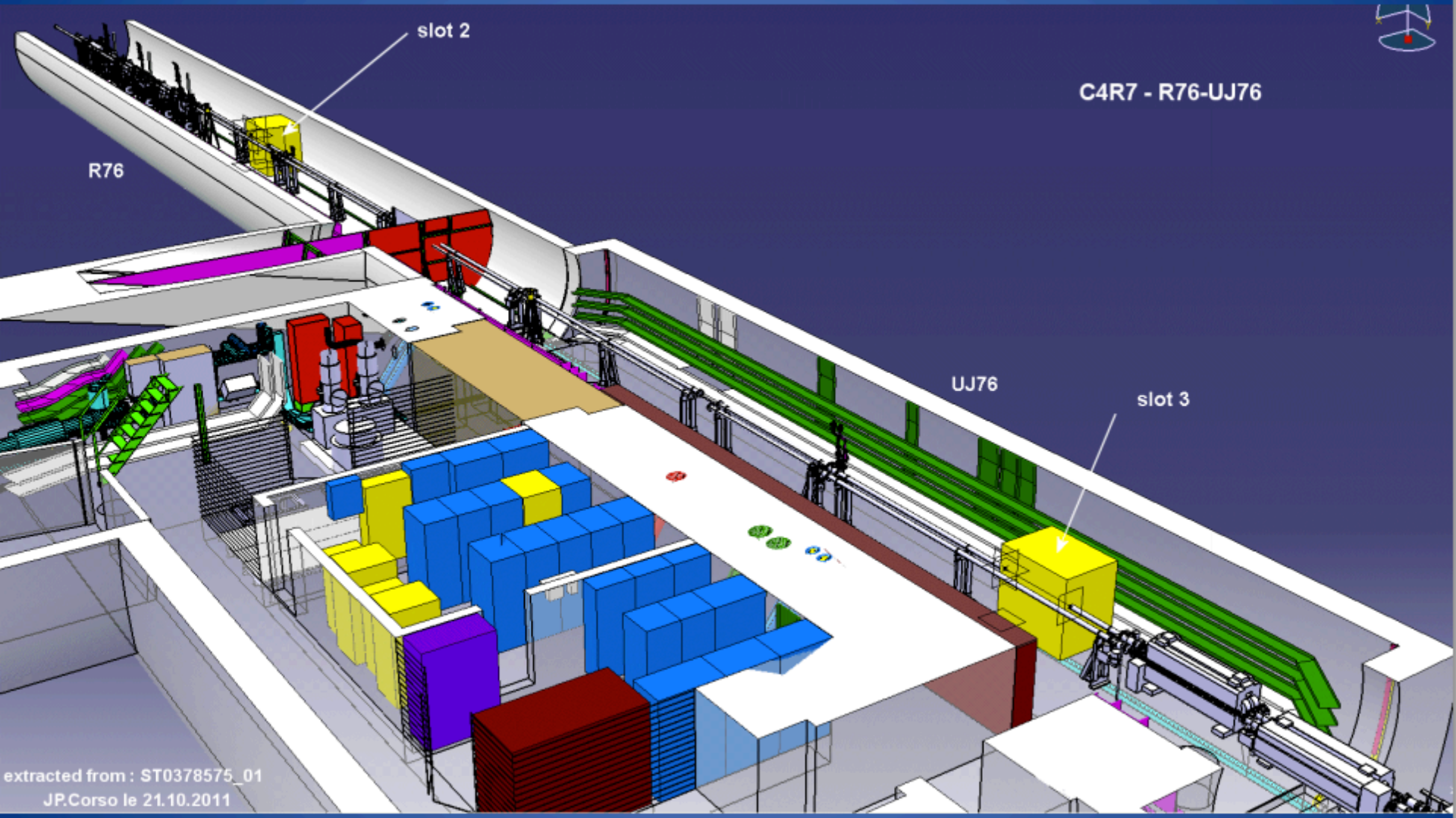
Kick = 32.5 µrad





2 drawbacks

- Hi rad area
- Tight space allowance

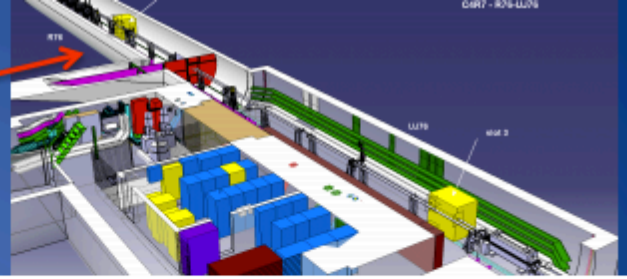

slot 2
C4R7 - R76-UJ76
R76
UJ76
slot 3
extracted from : ST0378575_01
JP.Corso le 21.10.2011

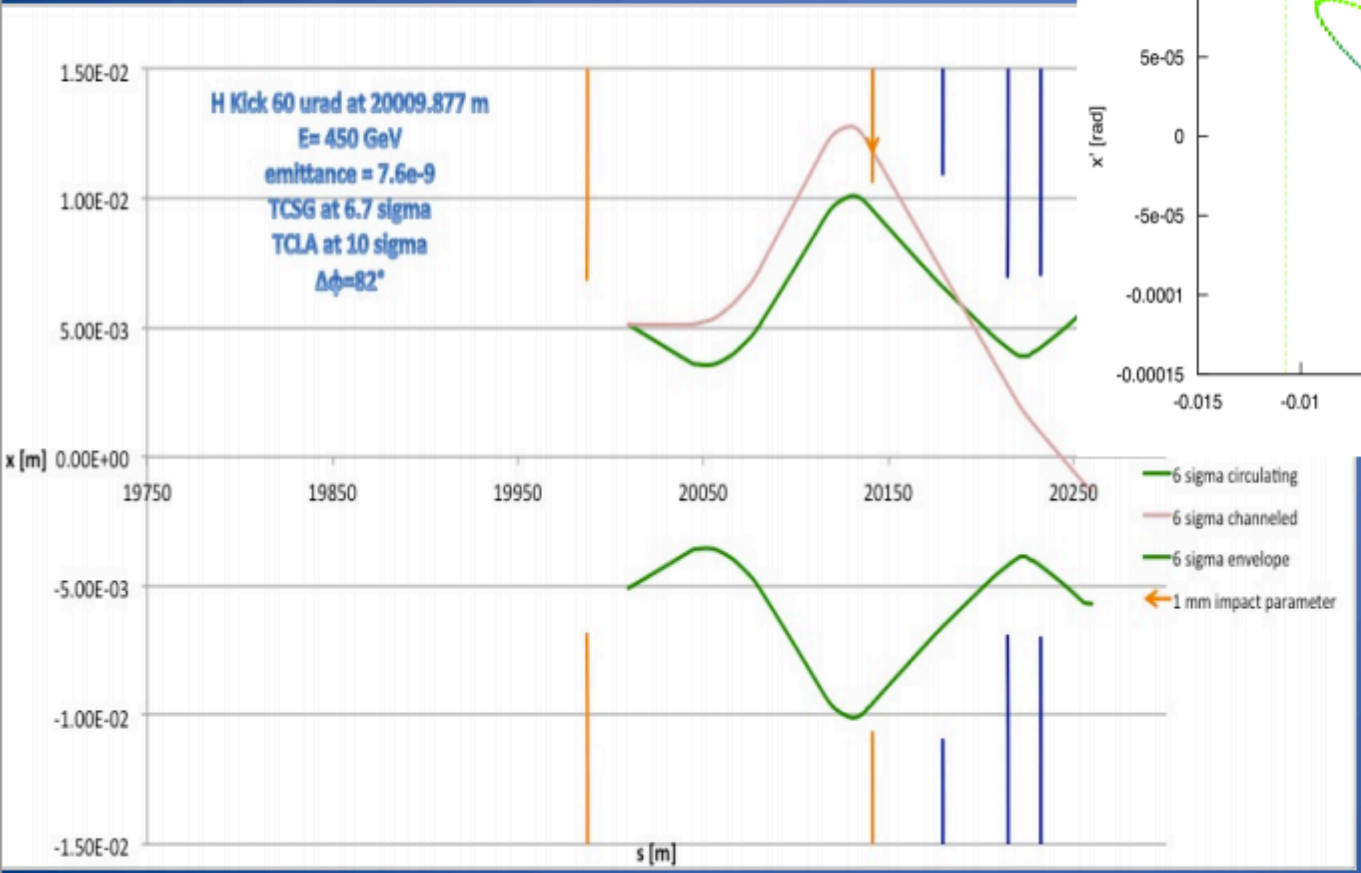
Upstream the Suggested location:

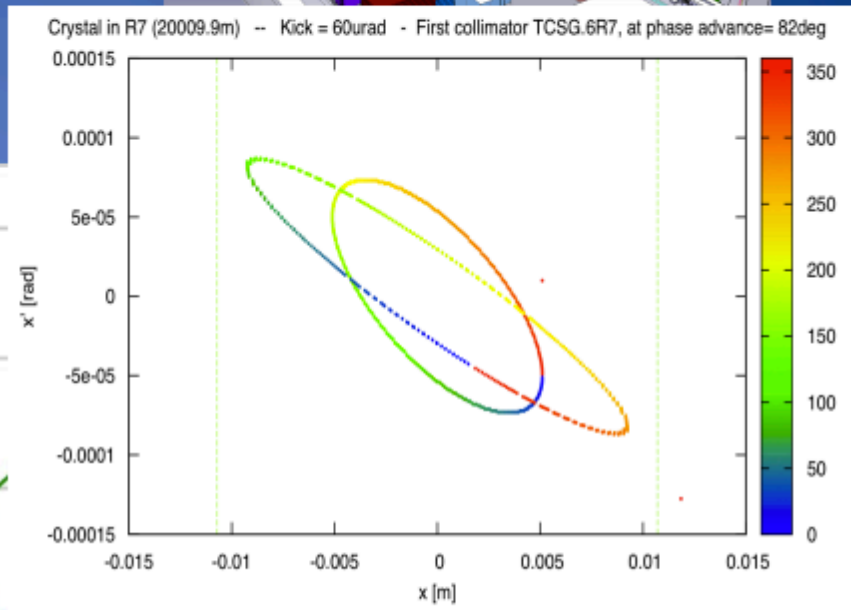
s=20010 m

Lower radiation and easy access via UJ76

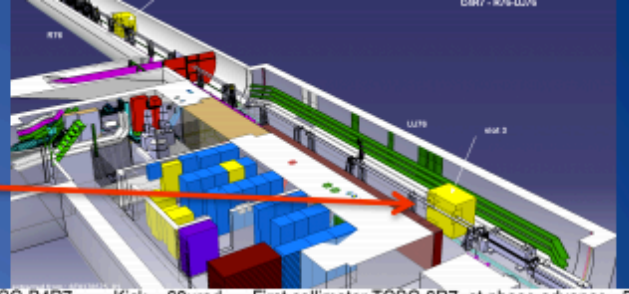
Kick = 60 µrad

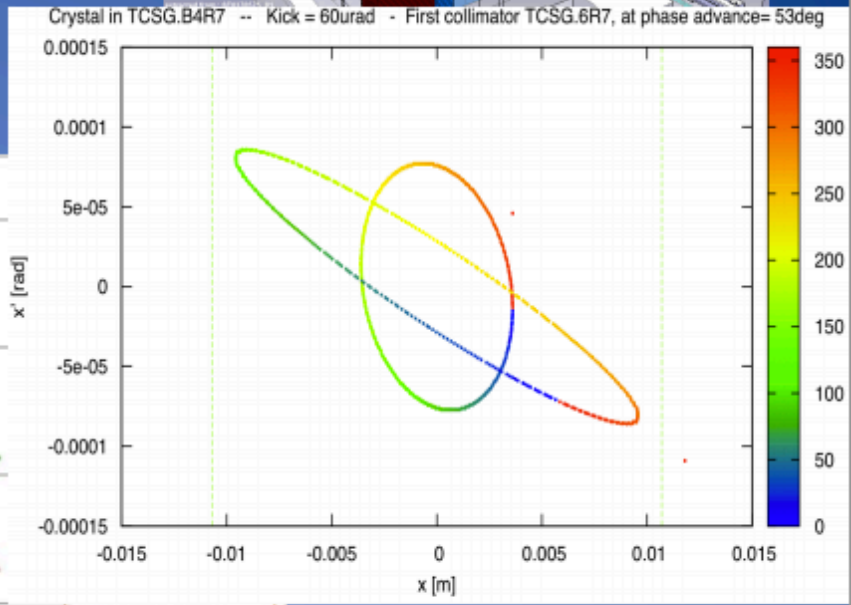


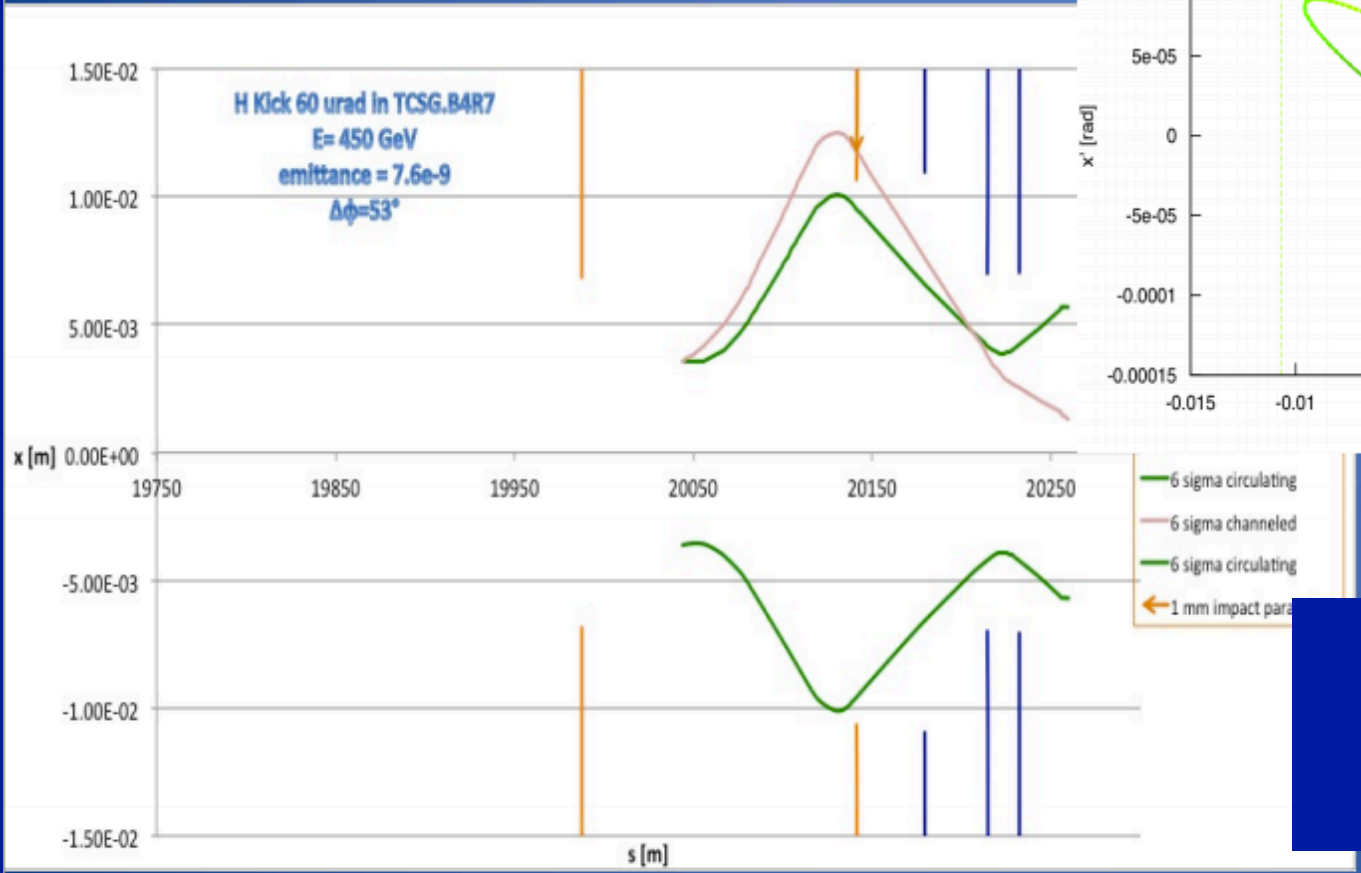




Suggested (R.A.) location:
TCSG.B4R7
Lower radiation and easy access via UJ76
Kick = 60 µrad







Strong kick

- The optimal kicks are again of the order of 50-60 urad

Conclusions

2 Layouts seem more appealing
- Crystal in TCP.A6L7 (radiation permitting)
- Crystal in L7 Prop2

with the same setup of
- Roman Pot (around s=20107m) and
- secondary collimator (TCSG.6R7 at s=20141m)

➢ Also IP3 will be evaluated as alternative option

Now the word is to LHC CERN people, in particular collimation, radiation, integration groups to
- Validate
- Approve
- Allow installation of UA9 in LHC

Further developments

Study the same configurations at high energy to find suitable kicks at all energies

Validate the layout with particle tracking simulations

Minimal installation?

- Given the present budget from CERN (300Kchf), it is foreseen an installation of a crystal collimation system in only 1 orientation (studies for H orientation)
- An additional effort of 200Kchf is required to have a full crystal collimation system (horizontal, vertical, skew)
- LARP possible contribution/participation in the project? (please contact Walter for discussion)